

Trauma System Development in a Theater of War: Experiences From Operation Iraqi Freedom and Operation Enduring Freedom

Brian J. Eastridge, MD, Donald Jenkins, MD, Stephen Flaherty, MD, Henry Schiller, MD, and John B. Holcomb, MD

Background: Medical lessons learned from Vietnam and previous military conflicts led to the development of civilian trauma systems in the United States. Operation Iraqi Freedom represents the first protracted, large-scale, armed conflict since the advent of civilian trauma systems in which to evaluate a similar paradigm on the battlefield.

Methods: Collaborative efforts between the joint military forces of the United States initiated development of a theater trauma system in May 2004. Formal implementation of the system occurred in November 2004, the collaborative effort of the three Surgeons General of the U.S. military, the United States

Army Institute of Surgical Research, and the American College of Surgeons Committee on Trauma. One trauma surgeon (Trauma System Director) and a team of six trauma nurse coordinators were deployed to theater to evaluate trauma system component issues. Demographic, mechanistic, physiologic, diagnostic, therapeutic, and outcome data were gathered for 4,700 injured patients using the Joint Theater Trauma Registry. Interview and survey methods were utilized to evaluate logistic aspects of the system.

Results: System implementation identified more than 30 systemic issues requiring policy development, research, education, evaluation of medical resource allocation,

and alterations in clinical care. Among the issues were transfer of casualties from point of injury to the most appropriate level of care, trauma clinical practice guidelines, standard forms, prophylactic antibiotic regimens, morbidity/mortality reporting, on-line medical evacuation regulation, improved data capture for the trauma registry, and implementation of a performance improvement program.

Conclusions: The implementation of a theater trauma system demonstrated numerous opportunities to improve the outcome of soldiers wounded on the battlefield.

Key Words: Battlefield, Combat, System, Trauma, Quality improvement, War.

J Trauma. 2006;61:●●●-●●●.

The development of trauma care has been a synergistic relationship between the military and civilian medical environments for the past two centuries.¹⁻³ During the Civil War, military physicians realized the utility of prompt attention to the wounded, early debridement, and amputation to mitigate the effects of tissue injury and infection and evacuation of the casualty from the battlefield. World War I saw further advances in the concept of evacuation and the development of echelons of medical care. With World War II, blood transfusion and resuscitative fluids were widely introduced into the combat environment and surgical practice was improved to care for wounded soldiers. From his World War II experiences, Dr. Michael DeBakey noted that wars have

always promoted advances in trauma care because of the concentrated exposure of military hospitals to large numbers of injured people during a relatively short span of time. Furthermore, this wartime medical experience has fostered a fundamental desire to improve outcomes by improving practice.⁴ In Vietnam, more highly trained medics at the point of wounding and prompt aeromedical evacuation decreased the battlefield mortality rate even further.⁵

In 1966, the National Academy of Sciences published "Accidental Death and Disability: The Neglected Disease of Modern Society," noting trauma to be one of the most significant public health problems faced by the nation. Concomitant with advances on the battlefield and the conclusions of the National Academy of Sciences was the formal development of civilian trauma centers. In 1976, the American College of Surgeons produced the first iteration of injury care guidelines, the "Optimal Resources for the Care of the Injured Patient." This concept rapidly evolved into the development of formal, integrated trauma systems. Trauma centers and trauma systems in the United States have had a remarkable impact on improving outcomes of injured patients,^{2,5-18} reducing mortality by up to 15% in mature systems.

However, despite the evolving successes of civilian trauma systems, Operations Desert Shield and Desert Storm in 1992 highlighted a number of issues in which the U.S. military had fallen behind the successful construct fostered by

Submitted for publication April 6, 2006.

Accepted for publication September 5, 2006.

Copyright © 2006 by Lippincott Williams & Wilkins, Inc.

From the Department of Surgery, US Army Institute for Surgical Research, San Antonio, Texas (B.J.E., J.B.H.); the Department of Surgery, Wilford Hall Medical Center, San Antonio, Texas (D.J.); the Department of Surgery, Womack Army Medical Center, Fayetteville, North Carolina (S.F.); and the Department of Surgery, Mayo Clinic, Rochester, Minnesota (H.S.).

Presented at the meeting of the American Association for the Surgery of Trauma, Atlanta, Georgia, September 2005.

Address for reprints: Brian J. Eastridge, MD, Brooke Army Medical Center, US Army Institute of Surgical Research, MCHE-SDI, 3851 Roger Brooke Drive, Ft Sam Houston, TX 78234.

DOI: 10.1097/01.ta.0000245894.78941.90

civilian systems of injury care. Inadequacies were formally noted in both preparation and delivery of trauma care in the combat environment.^{3,19–21} Shortly after the terrorist attacks of September 11, 2001, the United States once again had vast numbers of soldiers committed to armed conflict. At this juncture, the medical leadership of the joint forces enacted a plan to emplace a formal system of trauma care in theater to improve the care of the battlefield wounded. The goal was to develop and implement a true trauma system, modeled after the successes of civilian systems but modified to account for the realities of combat. The stated vision of the joint theater trauma system was to ensure that every soldier, marine, sailor, or airman injured on the battlefield has the optimal chance for survival and maximal potential for functional recovery. In other words, to get the right patient to the right place at the right time.

METHODS

The joint military forces of the United States initiated the development of a theater trauma system in May 2004. Initial groundwork included military surgical consultant visits to theater followed by the identification of a trauma surgeon (Trauma System Director) to be placed at the theater's medical command headquarters to introduce the concept and importance of establishing a trauma system in the theater of operations. After this preparatory phase, a collaborative effort of the Surgeons General of the U.S. military, United States Central Command, the United States Army Institute of Surgical Research, and the American College of Surgeons Committee on Trauma formally implemented the system in November 2004. A trauma system director and a team of six trauma nurse coordinators were deployed to the theater to address trauma system components and to organize the medical assets and identify discrete deficiencies within the existing medical infrastructure. A formal system performance improvement process was initiated. Injury data, including demographic, mechanistic, physiologic, diagnostic, therapeutic, and outcome data, were gathered using a Joint Theater Trauma Registry (JTTR). Interview and survey methods were utilized to evaluate logistic aspects of the system.

RESULTS

The initial charges of the system were identified as follows:

1. Recommend improvements to the trauma system to:
 - a. optimize placement of surgical assets within theater.
 - b. decrease the number of surgical sites within the theater.
 - c. develop triage criteria for casualty evacuation to get "the right patient to the right place at the right time."
 - d. develop and implement trauma practice guidelines.
2. Review and maintain the following:
 - a. JTTR
 - b. Morbidity and mortality reports shared between institutions
 - c. Operative case reports
3. Develop clinical information management scheme.
4. Implement a system of continuous performance improvement.
5. Develop/write a resource for optimal care of combat casualties, "green book" utilizing the Optimal Resources Gold Book²² as a template.

Derived from the Resources for Optimal Care handbook,²² component elements of the trauma system included prevention, point of wounding/battlefield care, and acute care facilities. To be complete and successful, the system implementation also mandated placement and evaluation of infrastructure elements including trauma leadership (impact of education on medical and tactical planning, etc.; path to leaders who make the decisions); professional resources; performance improvement; morbidity and mortality information management; research and education; and advocacy.

Prevention

Since the implementation of the military trauma system, the effect of new prevention measures has been most marked in the reduced number of soldiers killed from combat wounds, with current case fatality rates of 8.8% compared with 16.5% during Vietnam^{23,24} (Tables 1 and 2). The two primary modes of prevention are realistic and relevant pre-deployment training and personal protective equipment.

Numerous trauma training programs, including the Army, Air Force, and Navy Trauma Training Centers associated with nationally renowned Level I trauma centers, have evolved to train providers to treat combat injury and prepare them for the realities of medical care on the battlefield. Others courses, such as Tactical Combat Casualty Care, Emergency War Surgery, and the Joint Forces Combat Trauma Management Course, have revolutionized the way medical providers are trained for wartime deployment.

Data gathered about injury patterns has driven force protection changes in combatant training and equipment. The impact of the personal protective equipment (body armor) fielded during this conflict has been substantial. In an early interim analysis of casualties from January to July 2004, the rate of thoracic injury was 18% in patients without body armor and <5% in soldiers wearing armor. As the conflict transitioned from a maneuver war, in which most injuries were the result of gunshot wounds, to an insurgency characterized by ambushes and improvised explosive devices, wounding patterns changed from mainly small arms injuries

Table 1 Comparative US Combat Casualty Statistics

	World War II	Vietnam War	Iraq/Afghanistan
KIA (%)	23.7	21.3	12.5
DOW (%)	3.4	3.5	4.1
Total mortality (%)	22.8	16.5	8.8

KIA, killed in action; DOW, died of wounds; WIA, wounded in action.

Table 2 Iraq/Afghanistan US Combat Casualty Statistics

	WIA	RTD	Evacuated	DOW	KIA	Total Mortality
Total	13,383	6,482	6,618	283	986	8.8%

KIA, killed in action; DOW, died of wounds; WIA, wounded in action; RTD, return to duty.

to multiple fragment injuries. Rapid fielding initiatives led to the up armoring of military vehicles with anecdotal concomitant reports of a decrease in the number and severity of these types of injuries.²⁵

Battlefield Care

Most deaths on the battlefield are caused by total body disruption, severe brain injury, or hemorrhage. Little can be done on the battlefield for primary injury from total body disruption or severe brain injury. However, attention to hemorrhage control at the point of wounding is the focus of ongoing efforts. Responding to feedback from medics and corpsman on the battlefield, a number of products and therapeutic devices have been fielded to the battlefield for hemorrhage control, including new hemostatic dressings and newly tested and selected tourniquets.^{26,27} Reports from the battlefield thus far have documented efficacy of both dressings and tourniquets in the tactical environment similar to those in the literature.²⁸

Acute Care Facilities

The onset of Operation Iraqi Freedom was marked by a rapid ground influx of combat elements that required attached medical/surgical capability to support the fast-paced tempo of the conflict. Surgical support was initially ascribed to small surgical units such as the Army forward surgical team and the Navy forward resuscitative surgical system. Subsequently, more robust hospital elements with more operating room and intensive care unit capability were established throughout Iraq. With the increased capability came an increased capacity to render higher level care to soldiers injured on the battlefield. The larger hospital units were capable of operations 24 hours a day, 7 days a week, and could provide trauma care at a standard that would be expected of a major trauma center in the United States (Table 3).

Leadership

With the backing of the Central Command Surgeon and the three Surgeons General, the position of trauma system director was rapidly incorporated as a general staff position within the theater medical command. This leadership position enabled the trauma system director to rapidly implement actionable items such as data collection, implementation of standard practice guidelines, and performance improvement. A number of trauma clinical practice guidelines have now been instituted as standards of care within the theater trauma system, including deep vein thrombosis prophylaxis, prophylactic antibiotics, hypothermia prevention, and the manage-

Table 3 Comparison of Civilian and Military Trauma Center Levels

Military Designation*	Description	US Civilian Designation
V	Major trauma center with teaching and research	I
IV	Large trauma center	II
III	Regional trauma center, limited capability, 30-day ICU holding capability	III
IIB	Community hospital with limited emergency surgery capability	IV
IIA	Battalion aid station outpatient clinic	—
I	EMS/Corpsman/Medic	—

* Military trauma center levels are as follows: V, major US-based military hospital; IV, large, nontheater hospital (e.g., Landstuhl, Germany); III, e.g., theater hospitals in Iraq; IIB, e.g., Army Forward Surgical Team.

ment of specific battlefield injury patterns such as burn, vascular injury, and penetrating traumatic brain injury. To illustrate the efficacy of clinical practice guidelines in theater, the rate of hypothermia upon presentation has been decreased from 7% to <1% since inception. The leadership and administration of the combat trauma system is roughly analogous to the leadership hierarchy of the U.S. civilian trauma community (Table 4). These intrinsic leadership entities within the medical system drive advances within the trauma system by direct oversight of the medical processes and advocacy, which ultimately leads to better patient care.

Professional Resources

Professional resources are a finite and precious commodity, not only for the maintenance of the trauma system, but also for the medical care of injured warriors. Evaluation of the surgical assets in theater by the trauma system made a strong case for redeploying home many of the smaller surgical units after the larger combat support hospitals were established to conserve vital surgical resources, especially in light of the ongoing nature of the conflict and the likelihood of subsequent deployments for these individuals, approximately 65% of whom are Reserve soldiers.

In the context of the trauma system, it was rapidly determined that one trauma coordinator was needed for oversight at each combat support hospital to guarantee compliance with guidelines, improve information management, and enable data collection. Predeployment training for these individuals was performed under the guidance of the trauma coordinator and staff at the Brooke Army Medical Center and Wilford Hall Medical Center, the two Level I trauma centers in the Department of Defense. These trauma site coordinators have proven invaluable to the function of the combat trauma system.

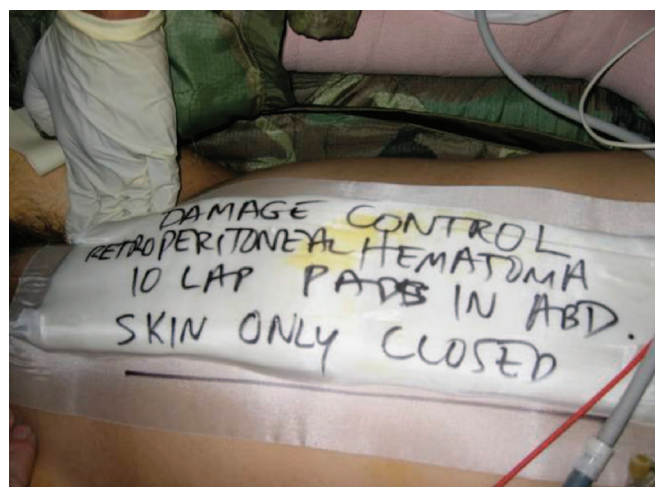
Table 4 Trauma System Organization

Civilian Trauma System Components		Military Trauma System Components
National/federal level	American College of Surgeons, Committee on Trauma <ul style="list-style-type: none"> - Registry (NTDB) - AAST/EAST/WEST (academic organizations influencing trauma care) 	Department of Defense, Health Affairs, Joint Surgeon's Office <ul style="list-style-type: none"> - Joint Theater Trauma Registry - Defense Medical Readiness Training Institute/Combat Trauma Surgery Committee/Committee on Tactical Combat Casualty Care
State/command level	State Trauma System <ul style="list-style-type: none"> - State Director (Texas: Governor's EMS and Trauma Advisory Committee Chair) - State registry - State Trauma System Plan 	Combatant Command (CENTCOM) <ul style="list-style-type: none"> - JTTR-derived data - Joint Theater Trauma System (JTTS)
Regional level	Regional Trauma Areas <ul style="list-style-type: none"> - registry Area of Responsibility (Operation Iraqi Freedom, Operation Enduring Freedom [Afghanistan]) - JTTR-derived AOR data 	
Local level	Lead Trauma Center <ul style="list-style-type: none"> - trauma registry JTTS Leadership - local trauma database, begin capture JTTR data 	
Local/regional components	Regional Advisory Council <ul style="list-style-type: none"> - RAC Chair - Rural/Urban Organizations - EMS (ground/air) - Hospital reps, all Levels - PI/Comm/Rehab/Prev 	MEDCOM/CENTAF/MEF Surgeon <ul style="list-style-type: none"> - JTTS director - Level II/III facilities - Level I/Medevac Battalion - Level II/III facilities - PI/Comm/Prev

Information Management

Multiple deficiencies were noted in all aspects of the information management and casualty information flow of injured patients. This immediate concern was one of the primary issues addressed by the system. One basic problem noted early in the evaluation was the relative paucity of clinical patient information, which was transferred to the next higher level of care. In many instances, for lack of a better method, surgeons wrote brief narratives in marker directly on patients' dressings to convey clinically relevant information (Figs. 1 and 2).

The reason for this lack of information flow was multifactorial, but included communication failures, operational tempo, casualty acuity, casualty load, etc. The goals at the system level were to improve clinical information flow, thereby minimizing the number of duplicate procedures at multiple levels of care and streamlining the continuity of care for soldiers being evacuated from the battlefield. Several strategies are currently being implemented to correct this problem, including universal serial bus memory devices and Internet-accessible electronic medical records. One particular instrument was developed

**Fig. 1.** Improvised patient information communication strategy.**Fig. 2.** Improvised patient information communication strategy.

in response to the trauma system demand. This tool known as the Joint Patient Tracking Application is a Web-based application that allows users to get real-time information about the status of injured troops as they make their way through the medical system.

The other aspects of information flow essential to the improved care of injured soldiers were the performance improvement project and registry data management currency. The performance improvement process was adopted at all combat support hospital sites and is being utilized to identify inadequacies in the evolving system. Registry data that was being completed at a 10% rate before the system is now being collected on >80% of casualties within the current theater of operations.

Research

Before the current conflict, much of the data on combat injury was derived from the Vietnam conflict and the Wound Data and Munitions Effectiveness Team database.^{29–31} Before the development of the formal combat trauma system, little data were being published about the conflict, and the data being published was largely small series and case reports.^{32–43} With the thought that research drives doctrine, a concerted effort was put forth to field the JTTR. This registry is a concise form developed to capture demographic, mechanistic, physiologic, diagnostic, therapeutic, and outcome data along with a brief physical examination (Fig. 3). To date, with improved registry capture as a direct result of the trauma system, the JTTR database contains >7,500 soldier injury

F3

Trauma Record									
For use of this form, see DoD Memo Subject Trauma Record, dtd 1 APR 04, the proponent agency is OTSG									
AUTHORITY: AR 40-66		PURPOSE: To provide a standard means of documenting all trauma care at echelons 1-3							
ROUTINE USES: The "Blanket Routine Uses" set forth at the beginning of the Army compilation of systems of records notice apply		DISCLOSURE: This is protected health information: HIPAA laws apply							
MIF DESIGNATION: Number TYPE		CASUALTY NAME: FIRST LAST		CASUALTY SSN: _____					
Arrive Date-Time Group (DTG):		Rank: _____		Date of Birth: _____		Gender: <input type="checkbox"/> Male <input type="checkbox"/> Female		Unit: _____	
ARRIVAL METHOD: <input type="checkbox"/> WALKED <input type="checkbox"/> CARRIED <input type="checkbox"/> Non-MED AIR <input type="checkbox"/> OTHER		<input type="checkbox"/> Non-MED GND <input type="checkbox"/> SHIP EVAC <input type="checkbox"/> GND AMB <input type="checkbox"/> AIR AMB		Nation <input type="checkbox"/> US <input type="checkbox"/> Host Nation <input type="checkbox"/> Enemy() <input type="checkbox"/> Coalition()		Service <input type="checkbox"/> Civilian <input type="checkbox"/> Combatant <input type="checkbox"/> Contractor <input type="checkbox"/> USA <input type="checkbox"/> USN <input type="checkbox"/> USMC <input type="checkbox"/> USAF <input type="checkbox"/> SOF <input type="checkbox"/> NGO () <input type="checkbox"/> Other			
Wound DTG:		PROTECTION: <input type="checkbox"/> UNK		<input type="checkbox"/> Not Worn <input type="checkbox"/> Worn <input type="checkbox"/> Struck <input type="checkbox"/> Penetrated		TRIAGE CATEGORY: <input type="checkbox"/> IMMEDIATE <input type="checkbox"/> DELAYED <input type="checkbox"/> MINIMAL <input type="checkbox"/> EXPECTANT			
WOUNDED BY: <input type="checkbox"/> US/COALITION(Nation _____) <input type="checkbox"/> ENEMY <input type="checkbox"/> CIVILIAN (Nation _____) <input type="checkbox"/> TRAINING <input type="checkbox"/> SELF ACCIDENT <input type="checkbox"/> SELF NON-ACCIDENT <input type="checkbox"/> SPORTS-RECREATION <input type="checkbox"/> OTHER		HELMET		FLAK VEST		CERAMIC PLATE		EYE PROTECTION	
		OTHER:							
MECHANISM OF INJURY: <input type="checkbox"/> GSW/BULLET <input type="checkbox"/> BLUNT TRAUMA <input type="checkbox"/> SINGLE FRAGMENT <input type="checkbox"/> MULTI FRAGMENT		<input type="checkbox"/> KNIFE / EDGE <input type="checkbox"/> BLAST <input type="checkbox"/> CRASH(a/c, veh, pe) <input type="checkbox"/> Chem/Rad/Nucl		<input type="checkbox"/> BURN (thermal, flash) <input type="checkbox"/> CRUSH <input type="checkbox"/> FALL <input type="checkbox"/> SMOKE Inhalation		<input type="checkbox"/> HEAT <input type="checkbox"/> COLD <input type="checkbox"/> BITE / STING <input type="checkbox"/> OTHER			
INJURY Description (Location, nature and size in cm)									
AM Amputation BL Bleeding D Deformity H Hematoma AV Avulsion B Burn F Foreign Body L Laceration P Puncture X Fracture S Stab Wnd G Gunsh Wnd									
OR Start DTG: _____ Stop DTG: _____ Vent On DTG: _____ Off DTG: _____		ICU in DTG: _____ Out DTG: _____							
PROVIDER: _____		SPECIALTY: _____							
TX & PROCEDURES: SEDATED _____ CHEM _____ PARALYZED _____ INTUBATED _____ CRIC _____ NEEDLE DECOMP _____ Chest Tube L R air/blood _____ IO line _____ COLLOID _____ ml CRYSTALLOID _____ LR/NS/HTS ml TOURNIQUET _____ Time on _____ Time off _____ Collar / C-spine _____ Back board _____ HEMOSTATIC DEVICE _____ OXYGEN _____ Liters/min RBC _____ Units FFP _____ Units CRYO _____ Units Pits _____ Packs Fresh Whole Bld _____ Units rFVIIa _____ mcg/kg EXT Fix /splint _____									

Fig. 3. Joint theater trauma registry record.

records as well as data on other individuals injured and cared for at US theater medical assets. The results being derived from this data will likely drive the course of combat trauma care for decades to come.

Ongoing joint military research efforts include the following:

- Personal protective gear
- Body armor extensions
- Kevlar helmet revisions
- Hemostasis
- Battlefield tourniquets
- Hemostatic dressings
- Recombinant factor VIIa
- Resuscitation
- Hypotensive resuscitation
- Hemostatic resuscitation
- O₂ therapeutics/hemoglobin-based oxygen carriers

Education and Advocacy

Combat injury is the most substantial healthcare issue in theater. Two-thirds of all evaluations at combat support hospitals are for injury. One goal of this system has been to educate soldiers, leaders, and medical providers and commanders with respect to the importance of maintaining the system that has been built. Coalition partners, including the British, have expressed sincere interest in broadening the system into a multinational coalition venture. The combat trauma system has become the standard of care on the battlefield.

CONCLUSIONS

The combat trauma system has improved combat casualty care to a level never seen before. However, a less tangible but nonetheless very real and practical impact of the combat trauma system is the effect it has on soldiers and families and morale. They can read in the newspaper or see on the television that combat soldiers injured on the battlefield have a greater chance than ever before of surviving their injuries and returning home. Although this marked improvement in outcomes is multifactorial, the continued evolution and development of a deployed trauma system will certainly have a lasting impact on the delivery of healthcare on the battlefield of today and the future. Full implementation of the joint theater trauma system will insure that the credo, "Right Patient, Right Place, Right Time", will be met and lives will continue to be saved as a consequence.

ACKNOWLEDGMENTS

All coauthors of the article have extensive contemporary battlefield experience and mutually participated in the conceptualization, development, and implementation of the joint theater trauma system.

REFERENCES

1. Tracy, E. Combining military and civilian trauma systems: the best of both worlds. *Top Emerg Med.* 2005;27:170–175.
2. Trunkey, DD. History and development of trauma care in the United States. *Clin Orthop Relat Res.* 2000;(374):36–46.
3. Trunkey, DD. In search of solutions. *J Trauma.* 2002;53:1189–1191.
4. DeBakey, ME. History, the torch that illuminates: lessons from military medicine. *Mil Med.* 1996;161:711–716.
5. Hoff WS, Schwab CW. Trauma system development in North America. *Clin Orthop Relat Res.* 2004;(422):17–22.
6. Demetriades D, Kimbrell B, Salim A, et al., Trauma deaths in a mature urban trauma system: is "trimodal" distribution a valid concept? *J Am Coll Surg.* 2005;201:343–348.
7. Jurkovich GJ, Mock C. Systematic review of trauma system effectiveness based on registry comparisons. *J Trauma.* 1999;47 (3 Suppl):S46–55.
8. Mann, NC. Assessing the effectiveness and optimal structure of trauma systems: a consensus among experts. *J Trauma.* 1999;47 (3 Suppl):S69–74.
9. Mann NC, Mullins RJ. Research recommendations and proposed action items to facilitate trauma system implementation and evaluation. *J Trauma.* 1999;47(3 Suppl):S75–78.
10. Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. *J Trauma.* 1999;47(3 Suppl):S25–33.
11. Mullins, RJ. A historical perspective of trauma system development in the United States. *J Trauma.* 1999;47(3 Suppl):S8–14.
12. Mullins RJ, Mann NC. Population-based research assessing the effectiveness of trauma systems. *J Trauma.* 1999;47(3 Suppl):S59–66.
13. Mullins RJ, Mann NC. Introduction to the Academic Symposium to Evaluate Evidence Regarding the Efficacy of Trauma Systems. *J Trauma.* 1999;47(3 Suppl):S3–7.
14. Mullins RJ, Veum-Stone J, Hedges JR, et al. Influence of a statewide trauma system on location of hospitalization and outcome of injured patients. *J Trauma.* 1996;40:536–545; discussion 545–546.
15. Nathens AB, Jurkovich GJ, Rivara FP, Maier RV. Effectiveness of state trauma systems in reducing injury-related mortality: a national evaluation. *J Trauma.* 2000;48:25–30; discussion 30–31.
16. O'Keefe GE, Jurkovich GJ, Copass M, Maier RV. Ten-year trend in survival and resource utilization at a level I trauma center. *Ann Surg.* 1999;229:409–415.
17. Trunkey, DD. Trauma care systems. *Emerg Med Clin North Am.* 1984;2:913–922.
18. West JG, Williams MJ, Trunkey DD, Wolferth CC Jr. Trauma systems. Current status-future challenges. *JAMA.* 1988;259:3597–3600.
19. Operation Desert Storm: Full army medical capability not achieved. Washington, DC: GAO/NSIAD-92–175, 1992.
20. War Time Medical Care: DOD is addressing capability shortfalls, but challenges remain. Washington, DC: GAO/NSIAD-96–224, 1996.
21. War Time Medical Care: Personnel requirements still not resolved. Washington, DC: GAO/NSIAD-96–173, 1996.
22. Resources for the optimal care of the injured patient. Chicago, IL: American College of Surgeons, 1999;135.
23. Holcomb JB, Stansbury LG, Champion HR, Wade C, Bellamy RF. Understanding combat casualty care statistics. *J Trauma.* 2006; 60:397–401.
24. Holcomb JB. The 2004 Fitts Lecture: current perspective on combat casualty care. *J Trauma.* 2005;59:990–1002.
25. Gondusky JS, Reiter MP. Protecting military convoys in Iraq: an examination of battle injuries sustained by a mechanized battalion during Operation Iraqi Freedom II. *Mil Med.* 2005;170:546–549.
26. Walters TJ, Mabry RL. Issues related to the use of tourniquets on the battlefield. *Mil Med.* 2005;170:770–775.
27. Wedmore I, McManus JG, Pusateri AE, Holcomb JB. A special report on the chitosan-based hemostatic dressing: experience in current combat operations. *J Trauma.* 2006;60:655–658.

AQ: 3

AQ: 4

28. Lakstein D, Blumenfeld A, Sokolov T, et al. Tourniquets for hemorrhage control on the battlefield: a 4-year accumulated experience. *J Trauma*. 2003;54(5 Suppl):S221–215.
29. Bellamy RF. The causes of death in conventional land warfare: implications for combat casualty care research. *Mil Med*. 1984; 149:55–62.
30. Bellamy RF. Contrasts in combat casualty care. *Mil Med*. 1985; 150:405–410.
31. Bellamy RF, Maningas PA, Vayer JS. Epidemiology of trauma: military experience. *Ann Emerg Med*. 1986;15:1384–1388.
32. Bilski TR, Baker BC, Grove JR, et al. Battlefield casualties treated at Camp Rhino, Afghanistan: lessons learned. *J Trauma*. 2003; 54:814–821.
33. Butler FK Jr, Hagmann J, Butler EG. Tactical combat casualty care in special operations. *Mil Med*. 1996;161(Suppl):3–16.
34. Chambers LW, Rhee P, Baker BC, et al. Initial experience of US Marine Corps forward resuscitative surgical system during Operation Iraqi Freedom. *Arch Surg*. 2005;140:26–32.
35. Cho JM, Jatoi I, Alarcon AS, Morton TM, King BT, Hermann JM. Operation Iraqi Freedom: surgical experience of the 212th Mobile Army Surgical Hospital. *Mil Med*. 2005;170:268–272.
36. Gawande A. Casualties of war: military care for the wounded from Iraq and Afghanistan. *N Engl J Med*. 2004;351:2471–2475.
37. Koehler RH, Smith RS, Bacaner T. Triage of American combat casualties: the need for change. *Mil Med*. 1994;159:541–547.
38. Mabry RL, Holcomb JB, Baker AM, et al. United States Army Rangers in Somalia: an analysis of combat casualties on an urban battlefield. *J Trauma*. 2000;49:515–528; discussion 528–529.
39. Patel TH, Wenner KA, Price SA, Weber MA, Leveridge A, McAtee SJ. A U.S. Army Forward Surgical Team's experience in Operation Iraqi Freedom. *J Trauma*. 2004;57:201–207.
40. Peake, JB. Beyond the purple heart-continuity of care for the wounded in Iraq. *N Engl J Med*. 2005;352:219–222.
41. Peoples GE, Jezior JR, Shriver CD. Caring for the wounded in Iraq: a photo essay. *N Engl J Med*. 2004;351:2476–2480.
42. Place RJ, Rush RM Jr, Arrington ED. Forward surgical team (FST) workload in a special operations environment: the 250th FST in Operation ENDURING FREEDOM. *Curr Surg*. 2003;60:418–422.
43. Stevens RA, Bohman HR, Baker BC, Chambers LW. The U.S. Navy's forward resuscitative surgery system during Operation Iraqi Freedom. *Mil Med*. 2005;170:297–301.

DISCUSSION

Dr. Donald D. Trunkey (Portland, Oregon): I think this article is very encouraging, because I think there has been a major change since Desert Storm. I believe, though, there are still some unsolved problems. I would like to have your comments. Has the military looked at how effective the civilian trauma training is for those who are in the active military?

My sense is it has been very positive. However, there may be another problem. At least a majority of the surgeons and anesthesiologists that come into the military from the reserve are not getting the same type of training, and their skills may not be equal to what you're being able to maintain in the active duty.

This becomes a further problem if you look at the other needs within the United States. Not only do we have to provide training for the reserves but then we have the DMAT (Disaster Medical Assistance Teams) and we have Homeland Security needs.

It seems to me that if we had the vision, we could put together a system that integrates all of these needs. I think we should have a pool of highly trained surgeons, anesthesiologists, and nurses who could solve all of these needs. By increasing by one-third the manpower in Level I trauma centers, we would create a "reserve pool".

Who pays for this? Well, I would argue that the military is already wasting some money with STRAP programs in order to attract people into the military. If you pooled these dollars and you got Health and Human Services and Homeland Security to put in some dollars, we could then have this reserve pool. It would be very similar to what the airline pilots do. They can get called back into active duty at any time. The airlines cooperate with this program. Similarly, if you had surgeons and anesthesiologists and nurses working in civilian trauma centers, you could pull out maybe up to a third at any given time to solve some of these needs.

The other thing that I identified, at least after Desert Storm, is that in military hospitals, critical care was being done by nonsurgeons. Maybe that's the model we should adopt; I, personally, don't think so, but I'd like your opinion about that, as well.

I was very encouraged by some of the things that you're doing from a system standpoint, and it is so logical to use the American College of Surgeons system's approach in the military.

Finally, I'm going to ask you a question you won't probably want to answer, but is this now the time that we should reconsider the purple suit? It seems to me the Surgeons General are now cooperating, and should we have a pool of surgeons who belong to really no branch but could be dispatched or placed anywhere in the world and fulfill what the military sees as their role.

Dr. Donald Jenkins (San Antonio, Texas): I think that the judgment would be that the civilian trauma center experience has been effective. Certainly, the opinion polls taken of those surgeons who have been through that site, the nurses and the medics, have gained tremendous amounts of hands-on experience they didn't otherwise get the opportunity to have.

They felt much more confident. I think that there is some clinical success that you see there in the first engagements that we have data for. As far as critical care, that's what we see as being the difference. I wasn't in Vietnam, but I judge that the ward that we have in that field hospital doesn't look a lot different. The difference in lives saved, I think, is over in the critical care end of that.

What can't be overlooked is the Air Force role in critical care air transport, where you could take a fellow with a damage control operation, triple amputation arriving with a blood pressure of 60, have a lifesaving damage control operation, three times in less than 40 hours: once in Iraq, once in Germany, and once in Walter Reed, and that kid then, 6 months later, is getting married, and walking without assistance on his prostheses. It is a tremendous success story.

So, I think critical care is definitely the way to go. As far as the purple suit idea goes, that would sort of be a Department of Defense level question that you know I'm not going to answer. But I will tell you this, I worked side-by-side with my Army colleagues at this hospital. That team up there was made of Australian neurosurgeons and Air Force general surgeons and Army nurses and British nurses, and we were about as close to a purple suit operation, I think, as you can get there in some of those facilities. So, I think there is merit to that, Sir.

Dr. Sheldon Brotman (Pittsfield, Massachusetts): You say that you have a PI program. I'd like to know how you're closing loops. Let's say you've got a triage problem with a certain unit. How do you get back to these people and how are you able to effectively monitor your problems?

Dr. Donald Jenkins (San Antonio, Texas): That is a 24/7 endeavor. We have one trauma nurse at each one of those Level III facilities. Their responsibility is to provide feedback down to those Level II institutions, as well as forward to the Level IV institutions.

We just held, for the first time, a three-continent performance improvement conference out of Iraq last week via the telephone with folks in San Antonio, folks in Germany, folks in Washington, DC, and folks down in Iraq, all on the phone together talking about some of those patients. So, it's old-fashioned hard work, stubby pencil, see the problem, come up with a solution set for that problem, call those folks forward. It's done on a regular basis. Lowell Chambers, down at Level II, I think, would be the first to say that it's in evolution, but it does work. Captain DeNobile (USN) and Colonel Flaherty are in Iraq actually working on this today.

Dr. David G. Burris (Bethesda, Maryland): For Don Trunkey's question, it was very interesting a year and a half ago, when a Tri-Service trauma surgeon group sat down and said, "What we need in theater is this kind of a guy" (a Theater Trauma Consultant). For that group to suggest that a "blue guy" (Air Force) suddenly go into a "green slot" (Army) in theater to make this happen shows that we are functioning as a purple suit, but maybe are not wearing a purple suit.

Don, some people ask me, "What does purple suit mean." So, if you would define that, and second, you mentioned the levels of care, and you mentioned "The Gold Book". Please discuss that a little bit because there is not a one-to-one correlation between Gold Book levels of care and military levels of care. I think that might be confusing for people, so I appreciate your discussion of that.

Dr. Donald Jenkins (San Antonio, Texas): The purple suit idea is that instead of each of the services having their

own medical corps (with the Navy serving not only the Navy but also the Marine Corps), you had one medical service that was joint, you could tap into that pool and they would go to any kind of engagement regardless of the troops that would be involved. I'm currently wearing pretty close to a purple suit. I've got this little Army medical department badge up here that was put on me by the Army Surgeon General; I speak a lot of Army now.

To answer the Army levels of care question, those ordinals are inverse from what we would consider in the United States. A Level I trauma center in the United States is a Level V facility for the US military. That's the burn center in San Antonio or Walter Reed Army Medical Center. These Level III facilities that we're talking about are more robust than Level III facilities, I think, that you would find here in the US system of things. It's somewhere between a II and a III with, again, 6 or 8 operating beds, 40 to 100 ward beds, half a dozen to 25 ICU beds at those places, with all the surgical capabilities.

Dr. Gregory Beilman (Minneapolis, Minnesota): Just a quick question. I noticed in my experience there that 70% to 80% of the patients we're caring for are Iraqis, Iraqi soldiers, MOI, and so on. How are you tracking outcomes with those patients compared to our soldiers?

Dr. Donald Jenkins (San Antonio, Texas): Yes, the local Iraqi population is a difficult endeavor to track down those outcomes. Things change over time, and we had the great luxury of being able to keep our patients for as long as they needed to be kept and see them back in follow up.

Some of that is changing today, so it does represent a significant challenge for us. If those patients are transferred out of that hospital today, you lose that follow-up on those individuals. The JTTR has the charts and will be entering the data of these Iraqi patients. Across the theater, 60% or more of all admitted casualties are non-US casualties; these patients will all eventually be captured in the JTTR.

Dr. Erwin F. Hirsch (Boston, Massachusetts): After the debriefings that occurred in the aftermath of Operation Desert Shield/Desert Storm, many questioned the ability of the Armed Forces to prepare its Medical Services in the care of combat casualties. I stand here to congratulate the authors of this article plus everybody else involved since the beginning of this operation, not only for the excellence in patient care, but in addition for the development of this system, which we in the civilian community should look at very seriously. I think very soon the paradigm that the civilians are training the military is going to change and that military lessons learned will apply to the care of nonmilitary patients.

AUTHOR QUERIES

AUTHOR PLEASE ANSWER ALL QUERIES

1

AQ1— Please confirm running head.

AQ2--- Sentence OK as edited? “After this preparatory phase...”

AQ8--- ED: OK to have same legend for both figs. 1 and 2?

AQ3--- Please provide authors of refs 19, 20, and 21.

AQ4--- Please provide author of ref 22.

AQ5--- Please expand STRAP on first use.

AQ6--- Please expand PI on first use.

AQ7--- Please expand all abbreviations on first use.

AQ9--- Please provide an email address.